

THE SHOULDER

Clinical Kinesiology of the Shoulder Complex: Foundations for Therapeutic Exercise

Independent Study Course 28.2.1

Phil Page, PT, PhD, ATC, CSCS, FACSM
Performance Health
Baton Rouge, LA



*Glenohumeral
abduction*

CONTINUING PHYSICAL THERAPY EDUCATION

ACADEMY OF
ORTHOPAEDIC
PHYSICAL THERAPY

APTA
American Physical Therapy Association

Leslie J. Hosstone

REFERENCES

1. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. *J Bone Joint Surg Am.* 2004;86-A(2):219-224.
2. Inman VT, Saunders JB, Abbott LC. Observations of the function of the shoulder joint. *J Bone Joint Surg Am.* 1944. 1996;(330):3-12.
3. Poppen NK, Walker PS. Forces at the glenohumeral joint in abduction. *Clin Orthop Relat Res.* 1978;(135):165-170.
4. Payne LZ, Deng XH, Craig EV, Torzilli PA, Warren RF. The combined dynamic and static contributions to subacromial impingement. A biomechanical analysis. *Am J Sports Med.* 1997;25(6):801-808.
5. Belling Sorensen AK, Jorgensen U. Secondary impingement in the shoulder. An improved terminology in impingement. *Scand J Med Sci Sports.* 2000;10(5):266-278.
6. Kibler WB. The role of the scapula in athletic shoulder function. *Am J Sports Med.* 1998;26(2):325-337.
7. Joshi M, Thigpen CA, Bunn K, Karas SG, Padua DA. Shoulder external rotation fatigue and scapular muscle activation and kinematics in overhead athletes. *J Athl Train.* 2011;46(4):349-357.
8. Doody SG, Freedman L, Waterland JC. Shoulder movements during abduction in the scapular plane. *Arch Phys Med Rehabil.* 1970;51(10):595-604.
9. Lucas DB. Biomechanics of the shoulder joint. *Arch Surg.* 1973;107(3):425-432.
10. Ludewig PM, Hoff MS, Osowski EE, Meschke SA, Rundquist PJ. Relative balance of serratus anterior and upper trapezius muscle activity during push-up exercises. *Am J Sports Med.* 2004;32(2):484-493.
11. van der Helm FC. Analysis of the kinematic and dynamic behavior of the shoulder mechanism. *J Biomech.* 1994;27(5):527-550.
12. Mottram SL. Dynamic stability of the scapula. *Man Ther.* 1997;2(3):123-131.
13. Bagg SD, Forrest WJ. A biomechanical analysis of scapular rotation during arm abduction in the scapular plane. *Am J Phys Med Rehabil.* 1988;67(6):238-245.
14. Johnson G, Bogduk N, Nowitzke A, House D. Anatomy and actions of the trapezius muscle. *Clin Biomech (Bristol, Avon).* 1994;9(1):44-50. doi: 10.1016/0268-0033(94)90057-4.
15. Labriola JE, Lee TQ, Debski RE, McMahan PJ. Stability and instability of the glenohumeral joint: the role of shoulder muscles. *J Shoulder Elbow Surg.* 2005;14(1 Suppl S):32S-38S.
16. Hung CJ, Jan MH, Lin YF, Wang TQ, Lin JJ. Scapular kinematics and impairment features for classifying patients with subacromial impingement syndrome. *Man Ther.* 2010;15(6):547-551. doi: 10.1016/j.math.2010.06.003. Epub 2010 Jul 7.
17. Poppen NK, Walker PS. Normal and abnormal motion of the shoulder. *J Bone Joint Surg Am.* 1976;58(2):195-201.
18. Warner JJ, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome. A study using Moire topographic analysis. *Clin Orthop Relat Res.* 1992;(285):191-199.
19. Paletta GA, Jr., Warner JJ, Warren RF, Deutsch A, Altchek DW. Shoulder kinematics with two-plane x-ray evaluation in patients with anterior instability or rotator cuff tearing. *J Shoulder Elbow Surg.* 1997;6(6):516-527.
20. Vermeulen HM, Stokdijk M, Eilers PH, Meskers CG, Rozing PM, Vliet Vlieland TP. Measurement of three dimensional shoulder movement patterns with an electromagnetic tracking device in patients with a frozen shoulder. *Ann Rheum Dis.* 2002;61(2):115-120.
21. Kibler WB, Ludewig PM, McClure PW, Michener LA, Bak K, Sciascia AD. Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the 'Scapular Summit'. *Br J Sports Med.* 2013;47(14):877-885. doi: 10.1136/bjsports-2013-092425. Epub 2013 Apr 11.
22. Timmons MK, Thigpen CA, Seitz AL, Karduna AR, Arnold BL, Michener LA. Scapular kinematics and subacromial-impingement syndrome: a meta-analysis. *J Sport Rehabil.* 2012;21(4):354-370. Epub 2012 Mar 2.
23. Keshavarz R, Bashardoust Tajali S, Mir SM, Ashrafi H. The role of scapular kinematics in patients with different shoulder musculoskeletal disorders: A systematic review approach. *J Bodyw Mov Ther.* 2017;21(2):386-400. doi: 10.1016/j.jbmt.2016.09.002. Epub 2016 Sep 12.
24. Rundquist PJ, Anderson DD, Guanche CA, Ludewig PM. Shoulder kinematics in subjects with frozen shoulder. *Arch Phys Med Rehabil.* 2003;84(10):1473-1479.
25. Fayad F, Roby-Brami A, Yazbeck C, et al. Three-dimensional scapular kinematics and scapulohumeral rhythm in patients with glenohumeral osteoarthritis or frozen shoulder. *J Biomech.* 2008;41(2):326-332. Epub 2007 Oct 18.
26. Rundquist PJ. Alterations in scapular kinematics in subjects with idiopathic loss of shoulder range of motion. *J Orthop Sports Phys Ther.* 2007;37(1):19-25.
27. Kebaetse M, McClure P, Pratt NA. Thoracic position effect on shoulder range of motion, strength, and three-dimensional scapular kinematics. *Arch Phys Med Rehabil.* 1999;80(8):945-950.
28. Finley MA, Lee RY. Effect of sitting posture on 3-dimensional scapular kinematics measured by skin-mounted electromagnetic tracking sensors. *Arch Phys Med Rehabil.* 2003;84(4):563-568.
29. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy.* 2003;19(6):641-661.
30. Morais NV, Pascoal AG. Scapular positioning assessment: is side-to-side comparison clinically acceptable? *Man Ther.*

- 2013;18(1):46-53. doi: 10.1016/j.math.2012.07.001. Epub 2012 Jul 23.
31. Laudner KG, Stanek JM, Meister K. Differences in scapular upward rotation between baseball pitchers and position players. *Am J Sports Med.* 2007;35(12):2091-2095. Epub 2007 Aug 8.
 32. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Scapular position and orientation in throwing athletes. *Am J Sports Med.* 2005;33(2):263-271.
 33. Kawasaki T, Yamakawa J, Kaketa T, Kobayashi H, Kaneko K. Does scapular dyskinesis affect top rugby players during a game season? *J Shoulder Elbow Surg.* 2012;21(6):709-714. doi: 10.1016/j.jse.2011.11.032. Epub 2012 Mar 21.
 34. Oyama S, Myers JB, Wassinger CA, Daniel Ricci R, Lephart SM. Asymmetric resting scapular posture in healthy overhead athletes. *J Athl Train.* 2008;43(6):565-570. doi: 10.4085/1062-6050-43.6.565.
 35. Cools AM, Johansson FR, Cambier DC, Velde AV, Palmans T, Witvrouw EE. Descriptive profile of scapulothoracic position, strength and flexibility variables in adolescent elite tennis players. *Br J Sports Med.* 2010;44(9):678-684. doi: 10.1136/bjism.2009.070128.
 36. Williams JG, Laudner KG, McLoda T. The acute effects of two passive stretch maneuvers on pectoralis minor length and scapular kinematics among collegiate swimmers. *Int J Sports Phys Ther.* 2013;8(1):25-33.
 37. Falla D, Farina D, Graven-Nielsen T. Experimental muscle pain results in reorganization of coordination among trapezius muscle subdivisions during repetitive shoulder flexion. *Exp Brain Res.* 2007;178(3):385-393. Epub 2006 Oct 19.
 38. Ludewig PM, Reynolds JF. The association of scapular kinematics and glenohumeral joint pathologies. *J Orthop Sports Phys Ther.* 2009;39(2):90-104. doi: 10.2519/jospt.2009.2808.
 39. Laudner K, Meister K, Noel B, Deter T. Anterior glenohumeral laxity is associated with posterior shoulder tightness among professional baseball pitchers. *Am J Sports Med.* 2012;40(5):1133-1137. doi: 10.1177/0363546512437522. Epub 2012 Feb 17.
 40. Manske R, Wilk KE, Davies G, Ellenbecker T, Reinold M. Glenohumeral motion deficits: friend or foe? *Int J Sports Phys Ther.* 2013;8(5):537-553.
 41. Muething A, Acocello S, Pritchard KA, Brockmeier SF, Saliba SA, Hart JM. Shoulder-muscle activation in individuals with previous shoulder injuries. *J Sport Rehabil.* 2015;24(3):278-285. doi: 10-1123/jsr.2014-0160. Epub 2015 Jan 5.
 42. Jerosch J, Castro WH, Sons HU, Moersler M. [Etiology of sub-acromial impingement syndrome--a biomechanical study]. *Beitr Orthop Traumatol.* 1989;36(9):411-418.
 43. Lin JJ, Lim HK, Yang JL. Effect of shoulder tightness on glenohumeral translation, scapular kinematics, and scapulohumeral rhythm in subjects with stiff shoulders. *J Orthop Res.* 2006;24(5):1044-1051.
 44. Borich MR, Bright JM, Lorello DJ, Cieminski CJ, Buisman T, Ludewig PM. Scapular angular positioning at end range internal rotation in cases of glenohumeral internal rotation deficit. *J Orthop Sports Phys Ther.* 2006;36(12):926-934.
 45. Cools AM, Witvrouw EE, De Clercq GA, et al. Scapular muscle recruitment pattern: electromyographic response of the trapezius muscle to sudden shoulder movement before and after a fatiguing exercise. *J Orthop Sports Phys Ther.* 2002;32(5):221-229.
 46. Cools AM, Witvrouw EE, Declercq GA, Danneels LA, Cambier DC. Scapular muscle recruitment patterns: trapezius muscle latency with and without impingement symptoms. *Am J Sports Med.* 2003;31(4):542-549.
 47. Cools AM, Witvrouw EE, Declercq GA, Vanderstraeten GG, Cambier DC. Evaluation of isokinetic force production and associated muscle activity in the scapular rotators during a protraction-retraction movement in overhead athletes with impingement symptoms. *Br J Sports Med.* 2004;38(1):64-68.
 48. Cools AM, Declercq GA, Cambier DC, Mahieu NN, Witvrouw EE. Trapezius activity and intramuscular balance during isokinetic exercise in overhead athletes with impingement symptoms. *Scand J Med Sci Sports.* 2007;17(1):25-33. Epub 2006 Jun 15.
 49. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. *Phys Ther.* 2000;80(3):276-291.
 50. Moraes GF, Faria CD, Teixeira-Salmela LF. Scapular muscle recruitment patterns and isokinetic strength ratios of the shoulder rotator muscles in individuals with and without impingement syndrome. *J Shoulder Elbow Surg.* 2008;17(1 Suppl):48S-53S. doi: 10.1016/j.jse.2007.08.007.
 51. Wadsworth DJ, Bullock-Saxton JE. Recruitment patterns of the scapular rotator muscles in freestyle swimmers with subacromial impingement. *Int J Sports Med.* 1997;18(8):618-624.
 52. Lin JJ, Wu YT, Wang SF, Chen SY. Trapezius muscle imbalance in individuals suffering from frozen shoulder syndrome. *Clin Rheumatol.* 2005;24(6):569-575. Epub 2005 May 18.
 53. Yesilyaprak SS, Yuksel E, Kalkan S. Influence of pectoralis minor and upper trapezius lengths on observable scapular dyskinesis. *Phys Ther Sport.* 2016;19:7-13. doi: 10.1016/j.ptsp.2015.08.002. Epub 2015 Aug 24.
 54. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. *J Orthop Sports Phys Ther.* 2005;35(4):227-238.
 55. Borstad JD. Resting position variables at the shoulder: evidence to support a posture-impairment association. *Phys Ther.* 2006;86(4):549-557.
 56. Page P, Frank CC, Lardner R. *Assessment and treatment of muscle imbalance: The Janda Approach.* Champaign, IL: Human Kinetics; 2010.
 57. Graichen H, Bonel H, Stammberger T, et al. Three-dimensional analysis of the width of the subacromial space in healthy subjects and patients with impingement syndrome. *AJR Am J Roentgenol.* 1999;172(4):1081-1086.
 58. Hallstrom E, Karrholm J. Shoulder kinematics in 25 patients

- with impingement and 12 controls. *Clin Orthop Relat Res.* 2006;448:22-27.
59. Deutsch A, Altchek DW, Schwartz E, Otis JC, Warren RF. Radiologic measurement of superior displacement of the humeral head in the impingement syndrome. *J Shoulder Elbow Surg.* 1996;5(3):186-193.
 60. Sharkey NA, Marder RA, Hanson PB. The entire rotator cuff contributes to elevation of the arm. *J Orthop Res.* 1994;12(5):699-708.
 61. Chen SK, Simonian PT, Wickiewicz TL, Otis JC, Warren RF. Radiographic evaluation of glenohumeral kinematics: a muscle fatigue model. *J Shoulder Elbow Surg.* 1999;8(1):49-52.
 62. Teyhen DS, Miller JM, Middag TR, Kane EJ. Rotator cuff fatigue and glenohumeral kinematics in participants without shoulder dysfunction. *J Athl Train.* 2008;43(4):352-358. doi: 10.4085/1062-6050-43.4.352.
 63. Muraki T, Aoki M, Izumi T, Fujii M, Hidaka E, Miyamoto S. Lengthening of the pectoralis minor muscle during passive shoulder motions and stretching techniques: a cadaveric biomechanical study. *Phys Ther.* 2009;89(4):333-341. doi: 10.2522/ptj.20080248. Epub 2009 Feb 26.
 64. Graichen H, Bonel H, Stammberger T, Englmeier KH, Reiser M, Eckstein F. Subacromial space width changes during abduction and rotation--a 3-D MR imaging study. *Surg Radiol Anat.* 1999;21(1):59-64.
 65. Hinterwimmer S, Von Eisenhart-Rothe R, Siebert M, et al. Influence of adducting and abducting muscle forces on the subacromial space width. *Med Sci Sports Exerc.* 2003;35(12):2055-2059.
 66. Graichen H, Hinterwimmer S, von Eisenhart-Rothe R, Vogl T, Englmeier KH, Eckstein F. Effect of abducting and adducting muscle activity on glenohumeral translation, scapular kinematics and subacromial space width in vivo. *J Biomech.* 2005;38(4):755-760.
 67. Reinold MM, Wilk KE, Fleisig GS, et al. Electromyographic analysis of the rotator cuff and deltoid musculature during common shoulder external rotation exercises. *J Orthop Sports Phys Ther.* 2004;34(7):385-394.
 68. Rathbun JB, Macnab I. The microvascular pattern of the rotator cuff. *J Bone Joint Surg Br.* 1970;52(3):540-553.
 69. Harryman DT 2nd, Sidles JA, Clark JM, McQuade KJ, Gibb TD, Matsen FA 3rd. Translation of the humeral head on the glenoid with passive glenohumeral motion. *J Bone Joint Surg Am.* 1990;72(9):1334-1343.
 70. Glousman R. Electromyographic analysis and its role in the athletic shoulder. *Clin Orthop Relat Res.* 1993;(288):27-34.
 71. Pappas AM, Zawacki RM, Sullivan TJ. Biomechanics of baseball pitching. A preliminary report. *Am J Sports Med.* 1985;13(4):216-222.
 72. Digiovine NM, Jobe FW, Pink M, Perry J. An electromyographic analysis of the upper extremity in pitching. *J Shoulder Elbow Surg.* 1992;1(1):15-25. doi: 10.1016/S1058-2746(09)80011-6. Epub 2009 Feb 2.
 73. Jobe FW, Tibone JE, Perry J, Moynes D. An EMG analysis of the shoulder in throwing and pitching. A preliminary report. *Am J Sports Med.* 1983;11(1):3-5.
 74. Jobe FW, Moynes DR, Tibone JE, Perry J. An EMG analysis of the shoulder in pitching. A second report. *Am J Sports Med.* 1984;12(3):218-220.
 75. Jobe FW, Moynes DR, Antonelli DJ. Rotator cuff function during a golf swing. *Am J Sports Med.* 1986;14(5):388-392.
 76. Nuber GW, Jobe FW, Perry J, Moynes DR, Antonelli D. Fine wire electromyography analysis of muscles of the shoulder during swimming. *Am J Sports Med.* 1986;14(1):7-11.
 77. Ryu RK, McCormick J, Jobe FW, Moynes DR, Antonelli DJ. An electromyographic analysis of shoulder function in tennis players. *Am J Sports Med.* 1988;16(5):481-485.
 78. Gowan ID, Jobe FW, Tibone JE, Perry J, Moynes DR. A comparative electromyographic analysis of the shoulder during pitching. Professional versus amateur pitchers. *Am J Sports Med.* 1987;15(6):586-590.
 79. McCann PD, Wootten ME, Kadaba MP, Bigliani LU. A kinematic and electromyographic study of shoulder rehabilitation exercises. *Clin Orthop Relat Res.* 1993;(288):179-188.
 80. Jaggi A, Malone AA, Cowan J, Lambert S, Bayley I, Cairns MC. Prospective blinded comparison of surface versus wire electromyographic analysis of muscle recruitment in shoulder instability. *Physiother Res Int.* 2009;14(1):17-29. doi: 10.1002/pri.407.
 81. Castelein B, Cagnie B, Parlevliet T, Cools A. Scapulothoracic muscle activity during elevation exercises measured with surface and fine wire EMG: A comparative study between patients with subacromial impingement syndrome and healthy controls. *Man Ther.* 2016;23:33-39. doi: 10.1016/j.math.2016.03.007. Epub 2016 Mar 22.
 82. Glousman R, Jobe F, Tibone J, Moynes D, Antonelli D, Perry J. Dynamic electromyographic analysis of the throwing shoulder with glenohumeral instability. *J Bone Joint Surg Am.* 1988;70(2):220-226.
 83. Hidalgo-Lozano A, Calderon-Soto C, Domingo-Camara A, Fernandez-de-Las-Penas C, Madeleine P, Arroyo-Morales M. Elite swimmers with unilateral shoulder pain demonstrate altered pattern of cervical muscle activation during a functional upper-limb task. *J Orthop Sports Phys Ther.* 2012;42(6):552-558. doi: 10.2519/jospt.2012.3875. Epub 2012 Jan 25.
 84. Hawkes DH, Alizadehkhayat O, Kemp GJ, Fisher AC, Roebuck MM, Frostick SP. Shoulder muscle activation and coordination in patients with a massive rotator cuff tear: an electromyographic study. *J Orthop Res.* 2012;30(7):1140-1146. doi: 10.1002/jor.22051. Epub 2011 Dec 30.
 85. Cools AM, Dewitte V, Lanszweert F, et al. Rehabilitation of scapular muscle balance: which exercises to prescribe? *Am J Sports Med.* 2007;35(10):1744-1751. Epub 2007 Jul 2.
 86. Michener LA, Sharma S, Cools AM, Timmons MK. Relative scapular muscle activity ratios are altered in subacromial pain syndrome. *J Shoulder Elbow Surg.* 2016;25(11):1861-1867. doi: 10.1016/j.jse.2016.04.010. Epub 2016 Jun 30.
 87. Reed D, Cathers I, Halaki M, Ginn K. Does supraspinatus initiate shoulder abduction? *J Electromyogr Kinesiol.*

- 2013;23(2):425-429. doi: 10.1016/j.jelekin.2012.11.008. Epub 2012 Dec 21.
88. Chester R, Smith TO, Hooper L, Dixon J. The impact of subacromial impingement syndrome on muscle activity patterns of the shoulder complex: a systematic review of electromyographic studies. *BMC Musculoskelet Disord.* 2010;11:45. doi: 10.1186/1471-2474-11-45.
 89. Worsley P, Warner M, Mottram S, et al. Motor control retraining exercises for shoulder impingement: effects on function, muscle activation, and biomechanics in young adults. *J Shoulder Elbow Surg.* 2013;22(4):e11-19. doi: 10.1016/j.jse.2012.06.010. Epub 2012 Sep 1.
 90. Leong HT, Ng GY, Chan SC, Fu SN. Rotator cuff tendinopathy alters the muscle activity onset and kinematics of scapula. *J Electromyogr Kinesiol.* 2017;35:40-46. doi: 10.1016/j.jelekin.2017.05.009. Epub 2017 May 30.
 91. Phadke V, Ludewig PM. Study of the scapular muscle latency and deactivation time in people with and without shoulder impingement. *J Electromyogr Kinesiol.* 2013;23(2):469-475. doi: 10.1016/j.jelekin.2012.10.004. Epub 2012 Nov 6.
 92. Yasojima T, Kizuka T, Noguchi H, Shiraki H, Mukai N, Miyanaga Y. Differences in EMG activity in scapular plane abduction under variable arm positions and loading conditions. *Med Sci Sports Exerc.* 2008;40(4):716-721. doi: 10.1249/MSS.0b013e31816073fb.
 93. Bitter NL, Clisby EF, Jones MA, Magarey ME, Jaberzadeh S, Sandow MJ. Relative contributions of infraspinatus and deltoid during external rotation in healthy shoulders. *J Shoulder Elbow Surg.* 2007;16(5):563-568. Epub 2007 Jun 8.
 94. Blackburn TA, McLeod WD, White B, Wofford L. EMG analysis of posterior rotator cuff exercises. *J Athl Train.* 1990;25(1):40-45.
 95. Townsend H, Jobe FW, Pink M, Perry J. Electromyographic analysis of the glenohumeral muscles during a baseball rehabilitation program. *Am J Sports Med.* 1991;19(3):264-272.
 96. Moseley JB Jr., Jobe FW, Pink M, Perry J, Tibone J. EMG analysis of the scapular muscles during a shoulder rehabilitation program. *Am J Sports Med.* 1992;20(2):128-134.
 97. Cricchio M, Frazer C. Scapulothoracic and scapulohumeral exercises: a narrative review of electromyographic studies. *J Hand Ther.* 2011;24(4):322-333; quiz 334. doi: 10.1016/j.jht.2011.06.001. Epub 2011 Aug 5.
 98. Youdas JW, Arend DB, Exstrom JM, Helmus TJ, Rozeboom JD, Hollman JH. Comparison of muscle activation levels during arm abduction in the plane of the scapula vs. proprioceptive neuromuscular facilitation upper extremity patterns. *J Strength Cond Res.* 2012;26(4):1058-1065. doi: 10.1519/JSC.0b013e31822e597f.
 99. Andersen LL, Andersen CH, Mortensen OS, Poulsen OM, Bjornlund IB, Zebis MK. Muscle activation and perceived loading during rehabilitation exercises: comparison of dumbbells and elastic resistance. *Phys Ther.* 2010;90(4):538-549. doi: 10.2522/ptj.20090167. Epub 2010 Feb 4.
 100. Lister JL, Del Rossi G, Ma F, et al. Scapular stabilizer activity during Bodyblade, cuff weights, and Thera-Band use. *J Sport Rehabil.* 2007;16(1):50-67.
 101. Witt D, Talbott N, Kotowski S. Electromyographic activity of scapular muscles during diagonal patterns using elastic resistance and free weights. *Int J Sports Phys Ther.* 2011;6(4):322-332.
 102. Aboodarda SJ, Page PA, Behm DG. Muscle activation comparisons between elastic and isoinertial resistance: A meta-analysis. *Clin Biomech (Bristol, Avon).* 2016;39:52-61. doi: 10.1016/j.clinbiomech.2016.09.008. Epub 2016 Sep 20.
 103. Hughes CJ, McBride A. The use of surface electromyography to determine muscle activation during isotonic and elastic resistance exercises for shoulder rehabilitation. *Orthopaedic Pract.* 2005;17(2):18-22.
 104. Wells SN, Schilz JR, Uhl TL, Gurney AB. A literature review of studies evaluating rotator cuff activation during early rehabilitation exercises for post-op rotator cuff repair. *J Exerc Physiol Online.* 2016;19(3):70-99.
 105. Gaunt BW, McCluskey GM, Uhl TL. An electromyographic evaluation of subdividing active-assistive shoulder elevation exercises. *Sports Health.* 2010;2(5):424-432.
 106. Mullaney MJ, Perkinson C, Kremenec I, Tyler TF, Orishimo K, Johnson C. EMG of shoulder muscles during reactive isometric elastic resistance exercises. *Int J Sports Phys Ther.* 2017;12(3):417-424.
 107. Escamilla RF, Yamashiro K, Paulos L, Andrews JR. Shoulder muscle activity and function in common shoulder rehabilitation exercises. *Sports Med.* 2009;39(8):663-685. doi: 10.2165/00007256-200939080-00004.
 108. Decker MJ, Hintermeister RA, Faber KJ, Hawkins RJ. Serratus anterior muscle activity during selected rehabilitation exercises. *Am J Sports Med.* 1999;27(6):784-791.
 109. Alizadehkhayat O, Hawkes DH, Kemp GJ, Frostick SP. Electromyographic analysis of the shoulder girdle musculature during external rotation exercises. *Orthop J Sports Med.* 2015;3(11):2325967115613988. doi: 10.1177/2325967115613988. eCollection 2015 Nov.
 110. Andersen CH, Zebis MK, Saervoll C, et al. Scapular muscle activity from selected strengthening exercises performed at low and high intensities. *J Strength Cond Res.* 2012;26(9):2408-2416. doi: 10.1519/JSC.0b013e31823f8d24.
 111. Schory A, Bidinger E, Wolf J, Murray L. A systematic review of the exercises that produce optimal muscle ratios of the scapular stabilizers in normal shoulders. *Int J Sports Phys Ther.* 2016;11(3):321-336.
 112. Castelein B, Cagnie B, Parlevliet T, Cools A. Serratus anterior or pectoralis minor: Which muscle has the upper hand during protraction exercises? *Man Ther.* 2016;22:158-164. doi: 10.1016/j.math.2015.12.002. Epub 2015 Dec 22.
 113. Park KM, Cynn HS, Kwon OY, Yi CH, Yoon TL, Lee JH. Comparison of pectoralis major and serratus anterior muscle activities during different push-up plus exercises in subjects with and without scapular winging. *J Strength Cond Res.* 2014;28(9):2546-2551. doi: 10.1519/JSC.000000000000443.

114. Page PA, Landin D, Thompson M. Comparison of isotonic and elastic resistance exercise on trapezius muscle balance in overhead athletes (Abstract). *J Orthop Sports Phys Ther.* 2011;41(1):A46.
115. Kibler WB, Sciascia AD, Uhl TL, Tambay N, Cunningham T. Electromyographic analysis of specific exercises for scapular control in early phases of shoulder rehabilitation. *Am J Sports Med.* 2008;36(9):1789-1798. doi: 10.1177/0363546508316281. Epub 2008 May 9.
116. Thigpen CA, Padua DA, Morgan N, Kreps C, Karas SG. Scapular kinematics during supraspinatus rehabilitation exercise: a comparison of full-can versus empty-can techniques. *Am J Sports Med.* 2006;34(4):644-652. Epub 2005 Nov 10.
117. Page PA, Ross O, Rogers ME, Rogers N. Muscle activity of the upper extremity during oscillation exercise using the Thera-Band Flexbar (Abstract). *Hand Prints.* 2004;21(5):7.
118. Kai Y, Gotoh M, Nagata K, Shiba N. Infraspinatus fatigue during resisted arm elevation with isometric contraction: an electromyographic study. *J Shoulder Elbow Surg.* 2012;21(8):1104-1109. doi: 10.1016/j.jse.2011.07.021. Epub 2011 Oct 29.
119. Ha SM, Kwon OY, Cynn HS, et al. Comparison of electromyographic activity of the lower trapezius and serratus anterior muscle in different arm-lifting scapular posterior tilt exercises. *Phys Ther Sport.* 2012;13(4):227-232. doi: 10.1016/j.ptsp.2011.11.002. Epub 2012 Jan 30.
120. Yamauchi T, Hasegawa S, Matsumura A, Nakamura M, Ibuki S, Ichihashi N. The effect of trunk rotation during shoulder exercises on the activity of the scapular muscle and scapular kinematics. *J Shoulder Elbow Surg.* 2015;24(6):955-964. doi: 10.1016/j.jse.2014.10.010. Epub 2015 Jan 1.
121. Uhl TL, Muir TA, Lawson L. Electromyographical assessment of passive, active assistive, and active shoulder rehabilitation exercises. *PM R.* 2010;2(2):132-141. doi: 10.1016/j.pmrj.2010.01.002.
122. De Mey K, Danneels L, Cagnie B, Van den Bosch L, Flier J, Cools AM. Kinetic chain influences on upper and lower trapezius muscle activation during eight variations of a scapular retraction exercise in overhead athletes. *J Sci Med Sport.* 2013;16(1):65-70. doi: 10.1016/j.jsams.2012.04.008. Epub 2012 May 31.
123. Maenhout A, Van Praet K, Pizzi L, Van Herzele M, Cools A. Electromyographic analysis of knee push up plus variations: what is the influence of the kinetic chain on scapular muscle activity? *Br J Sports Med.* 2010;44(14):1010-1015. doi: 10.1136/bjism.2009.062810. Epub 2009 Sep 14.
124. Ellenbecker TS, Kowalchuk C, Sueyoshi T, Johnson C, Page P, Bailie DS. Muscle activation during elastic and plyometric exercises in 90 degrees of glenohumeral joint abduction (Abstract). *J Orthop Sports Phys Ther.* 2008;38(1):A80-81.
125. Sperandei S, Barros MA, Silveira-Junior PC, Oliveira CG. Electromyographic analysis of three different types of lat pull-down. *J Strength Cond Res.* 2009;23(7):2033-2038. doi: 10.1519/JSC.0b013e3181b8d30a.
126. Trebs AA, Brandenburg JP, Pitney WA. An electromyography analysis of 3 muscles surrounding the shoulder joint during the performance of a chest press exercise at several angles. *J Strength Cond Res.* 2010;24(7):1925-1930. doi: 10.1519/JSC.0b013e3181ddfae7.
127. Paoli A, Marcolin G, Petrone N. Influence of different ranges of motion on selective recruitment of shoulder muscles in the sitting military press: an electromyographic study. *J Strength Cond Res.* 2010;24(6):1578-1583. doi: 10.1519/JSC.0b013e3181d756ea.
128. Yi CW, Shin JY, Kim YJ. The effects of finger extension on shoulder muscle activity. *J Phys Ther Sci.* 2015;27(9):2719-2721. doi: 10.1589/jpts.27.2719. Epub 2015 Sep 30.
129. Burkhart SS, Johnson TC, Wirth MA, Athanasiou KA. Cyclic loading of transosseous rotator cuff repairs: tension overload as a possible cause of failure. *Arthroscopy.* 1997;13(2):172-176.
130. Long JL, Ruberte Thiele RA, Skendzel JG, et al. Activation of the shoulder musculature during pendulum exercises and light activities. *J Orthop Sports Phys Ther.* 2010;40(4):230-237. doi: 10.2519/jospt.2010.3095.
131. Cools AM, Borms D, Cottens S, Himpe M, Meersdom S, Cagnie B. Rehabilitation exercises for athletes with biceps disorders and SLAP lesions: a continuum of exercises with increasing loads on the biceps. *Am J Sports Med.* 2014;42(6):1315-1322. doi: 10.1177/0363546514526692. Epub 2014 Mar 21.
132. Gurney AB, Mermier C, LaPlante M, et al. Shoulder electromyography measurements during activities of daily living and routine rehabilitation exercises. *J Orthop Sports Phys Ther.* 2016;46(5):375-383. doi: 10.2519/jospt.2016.6090. Epub 2016 Apr 6.
133. Hanratty CE, Kerr DP, Wilson IM, et al. Physical therapists' perceptions and use of exercise in the management of subacromial shoulder impingement syndrome: focus group study. *Phys Ther.* 2016;96(9):1354-1363. doi: 10.2522/ptj.20150427. Epub 2016 Mar 24.
134. Haik MN, Alburquerque-Sendin F, Moreira RF, Pires ED, Camargo PR. Effectiveness of physical therapy treatment of clearly defined subacromial pain: a systematic review of randomised controlled trials. *Br J Sports Med.* 2016;50(18):1124-1134. doi: 10.1136/bjsports-2015-095771. Epub 2016 Jun 10.
135. Brox JI, Gjengedal E, Uppheim G, et al. Arthroscopic surgery versus supervised exercises in patients with rotator cuff disease (stage II impingement syndrome): a prospective, randomized, controlled study in 125 patients with a 2 1/2-year follow-up. *J Shoulder Elbow Surg.* 1999;8(2):102-111.
136. Ketola S, Lehtinen J, Arnala I, et al. Does arthroscopic acromioplasty provide any additional value in the treatment of shoulder impingement syndrome?: a two-year randomised controlled trial. *J Bone Joint Surg Br.* 2009;91(10):1326-1334. doi: 10.1302/0301-620X.91B10.22094.
137. Holmgren T, Bjornsson Hallgren H, Oberg B, Adolffson L, Johansson K. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study. *BMJ.* 2012;344:e787. doi: 10.1136/bmj.e787.

138. Dickens VA, Williams JL, Bhamra MS. Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study. *Physiother*. 2005;91(3):159-164.
139. Dorrestijn O, Stevens M, Winters JC, van der Meer K, Diercks RL. Conservative or surgical treatment for subacromial impingement syndrome? A systematic review. *J Shoulder Elbow Surg*. 2009;18(4):652-660. doi: 10.1016/j.jse.2009.01.010. Epub 2009 Mar 14.
140. Ylinen J, Vuorenmaa M, Paloneva J, et al. Exercise therapy is evidence-based treatment of shoulder impingement syndrome. current practice or recommendation only. *Eur J Phys Rehabil Med*. 2013;49(4):499-505.
141. Kelly SM, Wrightson PA, Meads CA. Clinical outcomes of exercise in the management of subacromial impingement syndrome: a systematic review. *Clin Rehabil*. 2010;24(2):99-109. doi: 10.1177/0269215509342336.
142. Kuhn JE. Exercise in the treatment of rotator cuff impingement: a systematic review and a synthesized evidence-based rehabilitation protocol. *J Shoulder Elbow Surg*. 2009;18(1):138-160. doi: 10.1016/j.jse.2008.06.004. Epub 2008 Oct 2.
143. Ellenbecker TS, Cools A. Rehabilitation of shoulder impingement syndrome and rotator cuff injuries: an evidence-based review. *Br J Sports Med*. 2010;44(5):319-327. doi: 10.1136/bjsm.2009.058875.
144. Hanratty CE, McVeigh JG, Kerr DP, et al. The effectiveness of physiotherapy exercises in subacromial impingement syndrome: a systematic review and meta-analysis. *Semin Arthritis Rheum*. 2012;42(3):297-316. doi: 10.1016/j.semarthrit.2012.03.015. Epub 2012 May 18.
145. Shire AR, Staehr TAB, Overby JB, Bastholm Dahl M, Sandell Jacobsen J, Hoyrup Christiansen D. Specific or general exercise strategy for subacromial impingement syndrome-does it matter? A systematic literature review and meta analysis. *BMC Musculoskelet Disord*. 2017;18(1):158. doi: 10.1186/s12891-017-1518-0.
146. Littlewood C, May S, Walters S. A review of systematic reviews of the effectiveness of conservative interventions for rotator cuff tendinopathy. *Shoulder Elbow*. 2013;5(3):151-167.
147. Safran O, Schroeder J, Bloom R, Weil Y, Milgrom C. Natural history of nonoperatively treated symptomatic rotator cuff tears in patients 60 years old or younger. *Am J Sports Med*. 2011;39(4):710-714. doi: 10.1177/0363546510393944. Epub 2011 Feb 10.
148. Harris JD, Pedroza A, Jones GL, MOON Shoulder Group. Predictors of pain and function in patients with symptomatic, atraumatic full-thickness rotator cuff tears: a time-zero analysis of a prospective patient cohort enrolled in a structured physical therapy program. *Am J Sports Med*. 2012;40(2):359-366.
149. Ainsworth R, Lewis JS. Exercise therapy for the conservative management of full thickness tears of the rotator cuff: a systematic review. *Br J Sports Med*. 2007;41(4):200-210. Epub 2007 Jan 30.
150. Moosmayer S, Lund G, Seljom U, et al. Comparison between surgery and physiotherapy in the treatment of small and medium-sized tears of the rotator cuff: A randomised controlled study of 103 patients with one-year follow-up. *J Bone Joint Surg Br*. 2010;92(1):83-91. doi: 10.1302/0301-620X.92B1.22609.
151. Ainsworth R. Physiotherapy rehabilitation in patients with massive, irreparable rotator cuff tears. *Musculoskeletal Care*. 2006;4(3):140-151.
152. Kruschak G, Gebhard F, Reichel H, et al. A prospective randomized controlled trial comparing occupational therapy with home-based exercises in conservative treatment of rotator cuff tears. *J Shoulder Elbow Surg*. 2013;22(9):1173-1179. doi: 10.1016/j.jse.2013.01.008. Epub 2013 Mar 22.
153. Miller RM, Popchak A, Vyas D, et al. Effects of exercise therapy for the treatment of symptomatic full-thickness supraspinatus tears on in vivo glenohumeral kinematics. *J Shoulder Elbow Surg*. 2016;25(4):641-649. doi: 10.1016/j.jse.2015.08.048. Epub 2015 Nov 24.
154. Littlewood C, Bateman M, Brown K, et al. A self-managed single exercise programme versus usual physiotherapy treatment for rotator cuff tendinopathy: a randomised controlled trial (the SELF study). *Clin Rehabil*. 2016;30(7):686-696. doi: 10.1177/0269215515593784. Epub 2015 Jul 9.
155. Ha SM, Kwon OY, Yi CH, Cynn HS, Weon JH, Kim TH. Effects of scapular upward rotation exercises on alignment of scapula and clavicle and strength of scapular upward rotators in subjects with scapular downward rotation syndrome. *J Electromyogr Kinesiol*. 2016;26:130-136. doi: 10.1016/j.jelekin.2015.12.007. Epub 2015 Dec 22.
156. Burkhead WZ Jr, Rockwood CA Jr. Treatment of instability of the shoulder with an exercise program. *J Bone Joint Surg Am*. 1992;74(6):890-896.
157. Misamore GW, Sallay PI, Didelot W. A longitudinal study of patients with multidirectional instability of the shoulder with seven- to ten-year follow-up. *J Shoulder Elbow Surg*. 2005;14(5):466-470.
158. Warby SA, Pizzari T, Ford JJ, Hahne AJ, Watson L. Exercise-based management versus surgery for multidirectional instability of the glenohumeral joint: a systematic review. *Br J Sports Med*. 2016;50(18):1115-1123. doi: 10.1136/bjsports-2015-094970. Epub 2015 Dec 23.
159. Warby SA, Pizzari T, Ford JJ, Hahne AJ, Watson L. The effect of exercise-based management for multidirectional instability of the glenohumeral joint: a systematic review. *J Shoulder Elbow Surg*. 2014;23(1):128-142. doi: 10.1016/j.jse.2013.08.006.
160. Cools AM, Borms D, Castelein B, Vanderstukken F, Johansson FR. Evidence-based rehabilitation of athletes with glenohumeral instability. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(2):382-389. doi: 10.1007/s00167-015-3940-x. Epub 2015 Dec 24.
161. Watson L, Warby S, Balster S, Lenssen R, Pizzari T. The treatment of multidirectional instability of the shoulder with a rehabilitation programme: Part 2. *Shoulder Elbow*. 2017;9(1):46-53. doi: 10.1177/1758573216652087. Epub 2016 Jul 8.

162. Watson L, Warby S, Balster S, Lenssen R, Pizzari T. The treatment of multidirectional instability of the shoulder with a rehabilitation program: Part 1. *Shoulder Elbow*. 2016;8(4):271-278. doi: 10.1177/1758573216652086. Epub 2016 Jun 1.
163. Wong CK, Levine WN, Deo K, et al. Natural history of frozen shoulder: fact or fiction? A systematic review. *Physiotherapy*. 2017;103(1):40-47. doi: 10.1016/j.physio.2016.05.009. Epub 2016 Jun 21.
164. Levine WN, Kashyap CP, Bak SF, Ahmad CS, Blaine TA, Bigliani LU. Nonoperative management of idiopathic adhesive capsulitis. *J Shoulder Elbow Surg*. 2007;16(5):569-573. Epub 2007 May 24.
165. Sokk J, Gapeyeva H, Erelina J, Kolts I, Paasuke M. Shoulder muscle strength and fatigability in patients with frozen shoulder syndrome: the effect of 4-week individualized rehabilitation. *Electromyogr Clin Neurophysiol*. 2007;47(4-5):205-213.
166. Jewell DV, Riddle DL, Thacker LR. Interventions associated with an increased or decreased likelihood of pain reduction and improved function in patients with adhesive capsulitis: a retrospective cohort study. *Phys Ther*. 2009;89(5):419-429. doi: 10.2522/ptj.20080250. Epub 2009 Mar 6.
167. Jobe FW, Kvitne RS, Giangarra CE. Shoulder pain in the overhand or throwing athlete. The relationship of anterior instability and rotator cuff impingement. *Orthop Rev*. 1989;18(9):963-975.
168. Thigpen CA, Shaffer MA, Gaunt BW, Leggin BG, Williams GR, Wilcox RB 3rd. The American Society of Shoulder and Elbow Therapists' consensus statement on rehabilitation following arthroscopic rotator cuff repair. *J Shoulder Elbow Surg*. 2016;25(4):521-535. doi: 10.1016/j.jse.2015.12.018.
169. Hultenheim Klintberg I, Gunnarsson AC, Styf J, Karlsson J. Early activation or a more protective regime after arthroscopic subacromial decompression--a description of clinical changes with two different physiotherapy treatment protocols--a prospective, randomized pilot study with a two-year follow-up. *Clin Rehabil*. 2008;22(10-11):951-965. doi: 10.1177/0269215508090771.
170. Haering D, Blache Y, Raison M, Begon M. Mechanical risk of rotator cuff repair failure during passive movements: A simulation-based study. *Clin Biomech (Bristol, Avon)*. 2015;30(10):1181-1188. doi: 10.1016/j.clinbiomech.2015.08.006. Epub 2015 Aug 18.
171. Kluczynski MA, Isenburg MM, Marzo JM, Bisson LJ. Does early versus delayed active range of motion affect rotator cuff healing after surgical repair? a systematic review and meta-analysis. *Am J Sports Med*. 2016;44(3):785-791. doi: 10.1177/0363546515582032. Epub 2015 May 5.
172. Speer KP, Warren RE, Horowitz L. The efficacy of cryotherapy in the postoperative shoulder. *J Shoulder Elbow Surg*. 1996;5(1):62-68.
173. Kraeutler MJ, Reynolds KA, Long C, McCarty EC. Compressive cryotherapy versus ice-a prospective, randomized study on postoperative pain in patients undergoing arthroscopic rotator cuff repair or subacromial decompression. *J Shoulder Elbow Surg*. 2015;24(6):854-859. doi: 10.1016/j.jse.2015.02.004. Epub 2015 Mar 29.
174. Kaya E, Zinnuroglu M, Tugcu I. Kinesio taping compared to physical therapy modalities for the treatment of shoulder impingement syndrome. *Clin Rheumatol*. 2011;30(2):201-207. doi: 10.1007/s10067-010-1475-6. Epub 2010 Apr 30.
175. Kaya DO, Baltaci G, Toprak U, Atay AO. The clinical and sonographic effects of kinesiotaping and exercise in comparison with manual therapy and exercise for patients with subacromial impingement syndrome: a preliminary trial. *J Manipulative Physiol Ther*. 2014;37(6):422-432. doi: 10.1016/j.jmpt.2014.03.004. Epub 2014 Aug 6.
176. Simsek HH, Balki S, Keklik SS, Ozturk H, Elden H. Does Kinesio taping in addition to exercise therapy improve the outcomes in subacromial impingement syndrome? A randomized, double-blind, controlled clinical trial. *Acta Orthop Traumatol Turc*. 2013;47(2):104-110.
177. Shakeri H, Keshavarz R, Arab AM, Ebrahimi I. Clinical effectiveness of kinesiological taping on pain and pain-free shoulder range of motion in patients with shoulder impingement syndrome: a randomized, double blinded, placebo-controlled trial. *Int J Sports Phys Ther*. 2013;8(6):800-810.
178. Devereaux M, Velanoski KQ, Pennings A, Elmaraghy A. Short-term effectiveness of precut kinesiology tape versus an NSAID as adjuvant treatment to exercise for subacromial impingement: a randomized controlled trial. *Clin J Sport Med*. 2016;26(1):24-32. doi: 10.1097/JSM.0000000000000187.
179. Seth A, Matias R, Veloso AP, Delp SL. A biomechanical model of the scapulothoracic joint to accurately capture scapular kinematics during shoulder movements. *PLoS one*. 2016;11(1):e0141028. doi: 10.1371/journal.pone.0141028. eCollection 2016.
180. Muraki T, Yamamoto N, Zhao KD, et al. Effect of posteroinferior capsule tightness on contact pressure and area beneath the coracoacromial arch during pitching motion. *Am J Sports Med*. 2010;38(3):600-607. doi: 10.1177/0363546509350074. Epub 2009 Dec 4.
181. Laudner K, Compton BD, McLoda TA, Walters CM. Acute effects of instrument assisted soft tissue mobilization for improving posterior shoulder range of motion in collegiate baseball players. *Int J Sports Phys Ther*. 2014;9(1):1-7.
182. Tyler TF, Nicholas SJ, Lee SJ, Mullaney M, McHugh MP. Correction of posterior shoulder tightness is associated with symptom resolution in patients with internal impingement. *Am J Sports Med*. 2010;38(1):114-119. doi: 10.1177/0363546509346050. Epub 2009 Dec 4.
183. Manske RC, Meschke M, Porter A, Smith B, Reiman M. A randomized controlled single-blinded comparison of stretching versus stretching and joint mobilization for posterior shoulder tightness measured by internal rotation motion loss. *Sports Health*. 2010;2(2):94-100.
184. Tate AR, McClure PW, Young IA, Salvatori R, Michener LA. Comprehensive impairment-based exercise and manual therapy intervention for patients with subacromial

- impingement syndrome: a case series. *J Orthop Sports Phys Ther.* 2010;40(8):474-493. doi: 10.2519/jospt.2010.3223.
185. Rhon DI, Boyles RB, Cleland JA. One-year outcome of subacromial corticosteroid injection compared with manual physical therapy for the management of the unilateral shoulder impingement syndrome: a pragmatic randomized trial. *Ann Intern Med.* 2014;161(3):161-169. doi: 10.7326/M13-2199.
 186. Kromer TO, de Bie RA, Bastiaenen CH. Effectiveness of physiotherapy and costs in patients with clinical signs of shoulder impingement syndrome: One-year follow-up of a randomized controlled trial. *J Rehabil Med.* 2014;46(10):1029-1036. doi: 10.2340/16501977-1867.
 187. Mintken PE, McDevitt AW, Cleland JA, et al. Cervicothoracic manual therapy plus exercise therapy versus exercise therapy alone in the management of individuals with shoulder pain: a multicenter randomized controlled trial. *J Orthop Sports Phys Ther.* 2016;46(8):617-628. doi: 10.2519/jospt.2016.6319.
 188. Nordin M, Frankel VH. *Basic Biomechanics of the Musculoskeletal System.* 4th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2012.
 189. Wuelker N, Korell M, Thren K. Dynamic glenohumeral joint stability. *J Shoulder Elbow Surg.* 1998;7(1):43-52.
 190. Chopp JN, O'Neill JM, Hurley K, Dickerson CR. Superior humeral head migration occurs after a protocol designed to fatigue the rotator cuff: a radiographic analysis. *J Shoulder Elbow Surg.* 2010;19(8):1137-1144. doi: 10.1016/j.jse.2010.03.017. Epub 2010 Jul 3.
 191. Cote MP, Gomlinski G, Tracy J, Mazzocca AD. Radiographic analysis of commonly prescribed scapular exercises. *J Shoulder Elbow Surg.* 2009;18(2):311-316. doi: 10.1016/j.jse.2008.09.010. Epub 2009 Jan 7.
 192. Day A, Taylor NE, Green RA. The stabilizing role of the rotator cuff at the shoulder--responses to external perturbations. *Clin Biomech (Bristol, Avon).* 2012;27(6):551-556. doi: 10.1016/j.clinbiomech.2012.02.003. Epub 2012 Mar 4.
 193. David G, Magarey ME, Jones MA, Dvir Z, Turker KS, Sharpe M. EMG and strength correlates of selected shoulder muscles during rotations of the glenohumeral joint. *Clin Biomech (Bristol, Avon).* 2000;15(2):95-102.
 194. Guanche CA, Noble J, Solomonow M, Wink CS. Periarticular neural elements in the shoulder joint. *Orthopedics.* 1999;22(6):615-617.
 195. Steinbeck J, Bruntrup J, Greshake O, Potzl W, Filler T, Liljenqvist U. Neurohistological examination of the inferior glenohumeral ligament of the shoulder. *J Orthop Res.* 2003;21(2):250-255.
 196. Vangsness CT, Jr., Ennis M, Taylor JG, Atkinson R. Neural anatomy of the glenohumeral ligaments, labrum, and subacromial bursa. *Arthroscopy.* 1995;11(2):180-184.
 197. Guanche C, Knatt T, Solomonow M, Lu Y, Baratta R. The synergistic action of the capsule and the shoulder muscles. *Am J Sports Med.* 1995;23(3):301-306.
 198. Jerosch J, Castro WH, Halm H, Drescher H. Does the glenohumeral joint capsule have proprioceptive capability? *Knee Surg Sports Traumatol Arthrosc.* 1993;1(2):80-84.
 199. Ceegeer HE, van der Helm FC. Shoulder function: the perfect compromise between mobility and stability. *J Biomech.* 2007;40(10):2119-2129. Epub 2007 Jan 12.
 200. Irlenbusch U, Ganssen HK. Muscle biopsy investigations on neuromuscular insufficiency of the rotator cuff: a contribution to the functional impingement of the shoulder joint. *J Shoulder Elbow Surg.* 2003;12(5):422-426.
 201. Baskurt Z, Baskurt F, Gelecek N, Ozkan MH. The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome. *J Back Musculoskeletal Rehabil.* 2011;24(3):173-179. doi: 10.3233/BMR-2011-0291.
 202. Struyf F, Nijs J, Mollekens S, et al. Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial. *Clin Rheumatol.* 2013;32(1):73-85. doi: 10.1007/s10067-012-2093-2. Epub 2012 Oct 2.
 203. Mottram SL, Woledge RC, Morrissey D. Motion analysis study of a scapular orientation exercise and subjects' ability to learn the exercise. *Man Ther.* 2009;14(1):13-18. Epub 2007 Oct 1.
 204. De Mey K, Danneels LA, Cagnie B, Huyghe L, Seyns E, Cools AM. Conscious correction of scapular orientation in overhead athletes performing selected shoulder rehabilitation exercises: the effect on trapezius muscle activation measured by surface electromyography. *J Orthop Sports Phys Ther.* 2013;43(1):3-10. doi: 10.2519/jospt.2013.4283. Epub 2012 Nov 16.
 205. Myers JB, Oyama S. Sensorimotor training for shoulder injury. *Athl Train Sports Health Care.* 2009;1(5):199-208.
 206. Tucci HT, Ciol MA, de Araujo RC, et al. Activation of selected shoulder muscles during unilateral wall and bench press tasks under submaximal isometric effort. *J Orthop Sports Phys Ther.* 2011;41(7):520-525. doi: 10.2519/jospt.2011.3418. Epub 2011 Feb 2.
 207. Yoo WG, Hwang YI. Activation and ratio of the upper trapezius and serratus anterior muscles during dynamic and isometric exercises on various support surfaces. *J Phys Ther Sci.* 2010;22(3):267-271.
 208. Sandhu JS, Mahajan S, Shenoy S. An electromyographic analysis of shoulder muscle activation during push-up variations on stable and labile surfaces. *Int J Shoulder Surg.* 2008;2(2):30-35. doi: 10.4103/0973-6042.40456.
 209. de Oliveira AS, de Moraes Carvalho M, de Brum DP. Activation of the shoulder and arm muscles during axial load exercises on a stable base of support and on a medicine ball. *J Electromyogr Kinesiol.* 2008;18(3):472-479. Epub 2007 Jan 10.
 210. Lehman GJ, Gilas D, Patel U. An unstable support surface does not increase scapulothoracic stabilizing muscle activity during push up and push up plus exercises. *Man Ther.* 2008;13(6):500-506. Epub 2007 Jul 20.
 211. Kim SH, Kwon OY, Kim SJ, Park KN, Choung SD, Weon JH. Serratus anterior muscle activation during knee push-up

- plus exercise performed on static stable, static unstable, and oscillating unstable surfaces in healthy subjects. *Phys Ther Sport*. 2014;15(1):20-25. doi: 10.1016/j.ptsp.2013.01.001. Epub 2013 Aug 20.
212. Park SY, Yoo WG. Differential activation of parts of the serratus anterior muscle during push-up variations on stable and unstable bases of support. *J Electromyogr Kinesiol*. 2011;21(5):861-867. doi: 10.1016/j.jelekin.2011.07.001. Epub 2011 Jul 31.
213. Chulvi-Medrano I, Martinez-Ballester E, Masia-Tortosa L. Comparison of the effects of an eight-week push-up program using stable versus unstable surfaces. *Int J Sports Phys Ther*. 2012;7(6):586-594.
214. Parry JS, Straub R, Cipriani DJ. Shoulder- and back-muscle activation during shoulder abduction and flexion using a Bodyblade Pro versus dumbbells. *J Sport Rehabil*. 2012;21(3):266-272. Epub 2012 Jun 18.
215. Sanchez-Zuriaga D, Vera-Garcia FJ, Moreside JM, McGill SM. Trunk muscle activation patterns and spine kinematics when using an oscillating blade: influence of different postures and blade orientations. *Arch Phys Med Rehabil*. 2009;90(6):1055-1060. doi: 10.1016/j.apmr.2008.12.015.
216. Arora S, Button DC, Basset FA, Behm DG. The effect of double versus single oscillating exercise devices on trunk and limb muscle activation. *Int J Sports Phys Ther*. 2013;8(4):370-380.
217. Moreside JM, Vera-Garcia FJ, McGill SM. Trunk muscle activation patterns, lumbar compressive forces, and spine stability when using the bodyblade. *Phys Ther*. 2007;87(2):153-163. Epub 2007 Jan 23.
218. Ellenbecker TS, Pieczynski T, Bailie DS, Page P. Analysis of rotator cuff and scapular muscle activation during elastic resistance, external rotation oscillation, and band walk exercises (Abstract). *J Orthop Sports Phys Ther*. 2012;42(1):A42.
219. Bernhardsson S, Klintberg IH, Wendt GK. Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome. *Clin Rehabil*. 2011;25(1):69-78. doi: 10.1177/0269215510376005. Epub 2010 Aug 16.
220. Maenhout AG, Mahieu NN, De Muynck M, De Wilde LF, Cools AM. Does adding heavy load eccentric training to rehabilitation of patients with unilateral subacromial impingement result in better outcome? A randomized, clinical trial. *Knee Surg Sports Traumatol Arthrosc*. 2013;21(5):1158-1167. doi: 10.1007/s00167-012-2012-8. Epub 2012 May 12.
221. Huang HY, Lin JJ, Guo YL, Wang WT, Chen YJ. EMG biofeedback effectiveness to alter muscle activity pattern and scapular kinematics in subjects with and without shoulder impingement. *J Electromyogr Kinesiol*. 2013;23(1):267-274. doi: 10.1016/j.jelekin.2012.09.007. Epub 2012 Nov 2.
222. Castelein B, Cagnie B, Parlevliet T, Cools A. Superficial and deep scapulothoracic muscle electromyographic activity during elevation exercises in the scapular plane. *J Orthop Sports Phys Ther*. 2016;46(3):184-193. doi: 10.2519/jospt.2016.5927. Epub 2016 Feb 11.
223. Cools AM, Struyf F, De Mey K, Maenhout A, Castelein B, Cagnie B. Rehabilitation of scapular dyskinesis: from the office worker to the elite overhead athlete. *Br J Sports Med*. 2014;48(8):692-697. doi: 10.1136/bjsports-2013-092148. Epub 2013 May 18.
224. Chinkle J, Nesser TW, Demchak TJ, McMannus DM. Effect of core strength on the measure of power in the extremities. *J Strength Cond Res*. 2012;26(2):373-380. doi: 10.1519/JSC.0b013e31822600e5.
225. Sueki DG, Cleland JA, Wainner RS. A regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. *J Man Manip Ther*. 2013;21(2):90-102. doi: 10.1179/2042618612Y.0000000027.
226. Zattara M, Bouisset S. Posturo-kinetic organisation during the early phase of voluntary upper limb movement. 1. Normal subjects. *J Neurol Neurosurg Psychiatry*. 1988;51(7):956-965.
227. Oliver GD, Weimar WH, Plummer HA. Gluteus medius and scapula muscle activations in youth baseball pitchers. *J Strength Cond Res*. 2015;29(6):1494-1499. doi: 10.1519/JSC.0000000000000797.
228. McMullen J, Uhl TL. A kinetic chain approach for shoulder rehabilitation. *J Athl Train*. 2000;35(3):329-337.
229. Garcia-Masso X, Colado JC, Gonzalez LM, et al. Myoelectric activation and kinetics of different plyometric push-up exercises. *J Strength Cond Res*. 2011;25(7):2040-2047. doi: 10.1519/JSC.0b013e3181e4f7ce.
230. Maenhout A, Benzoor M, Werin M, Cools A. Scapular muscle activity in a variety of plyometric exercises. *J Electromyogr Kinesiol*. 2016;27:39-45. doi: 10.1016/j.jelekin.2016.01.003. Epub 2016 Jan 28.
231. Cordasco FA, Wolfe IN, Wootten ME, Bigliani LU. An electromyographic analysis of the shoulder during a medicine ball rehabilitation program. *Am J Sports Med*. 1996;24(3):386-392.